THE

USE OF THE

HYDROSTATIC BALANCE

BECKET

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HYDROSTATIC BALANCE

MADE EASY:

AND

Applied particularly to the Purpoſe of detecting counterfeit GOLD COIN.

With ſeveral TABLES and CALCULATIONS relative to the Weight of GOLD.

By J. B. BECKET.

BRISTOL:

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PREFACE.

FROM the gradual advancement of human knowledge, and the various aſſiſtances that are found neceſſary to the perfection of every material diſcovery, it is never to be expected that the firſt diſcoverer of any ſcience, ſhould be able to place it in ſo advantageous a point of view, as to render it at once diſtinct, and extenſively uſeful.

THE DISCOVERER ſufficiently eſtabliſhes his credit, if he is able to demonſtrate the truth of his THEORY, and but ſeldom attempts giving to the world a practical or introductory treatiſe on the ſubject. This has generally fallen to the lot of thoſe who have been contented to follow the track marked out for them by a ſuperior hand; till experience has, at length, taught them that, in order to purſue the enquiry to advantage, they are ſometimes obliged to make various *deviations* from the old track; and, finding it neceſſary to obtain a more diſtinct view of the ſeparate parts of their ſubject, they have proceeded, by experiment and inveſtigation, to form a regular analyſis of the whole. This has generally thrown a ſtronger light upon the object, and it has appeared clear and ſatisfactory to every attentive obſerver: But, as new experiments are continually leading to new diſcoveries, we are, after all, conſtrained to conclude, that almoſt every branch of practical ſcience admits of unlimited improvement.

IT is evident that thoſe arts have approached the neareſt to perfection, that have been illuſtrated by the moſt familiar deſcriptions, ſo as to render them plain and intelligible to

every

every enquirer. YOUTH have, by ſuch means, been agreeably led on in their purſuits of *ſcience*; and, ſince *this* has been exhibited with rather leſs *ſyſtematic dignity* than formerly, the man of inferior capacity has eaſily acquired the moſt uſeful part of that knowledge, which was once deemed peculiar to the PHILOSOPHER.

THERE is, at leaſt, one farther advantage ariſing from plain and familiar analyſes,—that they have an immediate tendency to diffuſe a knowledge of the uſeful arts among all claſſes of mankind; whereby every one may have it in his power, to compare the different effects ariſing from the different ſituations of things; and the artiſt not only gains the beſt information of thoſe who have gone before him, but is likely to be led into the moſt ſure track for making farther diſcoveries and improvements.

THE ſcience of HYDROSTATICS, comprehending the nature of *fluids* in general, has been ſtudied and cultivated by the moſt ingenious men, as a ſource of agreeable entertainment, and of extenſive utility; being applicable to the moſt neceſſary and common occaſions of life; and the *theory* having been already made ſufficiently clear by various writers on the ſubject, my preſent deſign is merely to draw up a plain compendium of the principal uſes of the HYDROSTATIC BALANCE, in order to facilitate the practice of this uſeful inſtrument to thoſe who are unacquainted with it.

THIS appears to be the more neceſſary at preſent, becauſe, in the circulation of *money*, the public are now more liable to be deceived by that which is *counterfeit*, than by that which has been fraudulently rendered ſhort of weight. The late ſalutary regulation reſpecting the weight of gold coin, having effectually prevented the iniquitous practice of CLIPPING, the only remaining expedient for the *deſtroyers* of money, ſeems

ſeems to be that of *making* it;—but were the uſe of the hydroſtatic balance to become general, it would undoubtedly put as effectual a ſtop to baſe and counterfeit COINING; and in this light it appears to be an object worthy of conſiderable attention.

IT is ſomewhat to be regretted, that moſt explanations of the uſe of this inſtrument, appear frequently enveloped in a cloud of mathematical calculations, which has doubtleſs prevented many from uſing it, or giving any attention to the ſubject. This method, indeed, is commonly made uſe of by thoſe who have been converſant in ſuch ſtudies, becauſe *quantities* may be more conciſely expreſſed this way than by common arithmetic. But a knowledge of mathematics is by no means neceſſary to that of the hydroſtatic balance, which may be uſed to very good purpoſe by every perſon who is capable of uſing a pair of common ſcales.

WERE the queſtion to be put to many people who have been deceived by counterfeit money, "Why don't you furniſh yourſelf with a Hydroſtatic Balance?" The probable anſwer would be, "I know nothing of hydroſtatics, and "ſhould ſcarcely be able to uſe one properly—beſides, they "are troubleſome, and perhaps not always to be depended "upon."—The fact is, that theſe balances have been made of ſo many different forms, ſome of them ſo inconvenient and tedious in the operation, and others ſo extremely inadequate to the purpoſe, that many perſons who are unacquainted with the principles, ſeem dubious of the real utility of any of them.

PERHAPS the only conſtruction that may at all times be relied on, is that of the *equal Lever*, in the form of a common ſcale-beam;—this is likewiſe the moſt ſimple and eaſy in its application, and might be rendered altogether as portable as any other kind.

P R E F A C E.

In the following ſmall tract, I have endeavoured to render the uſe of this balance, in determining the ſpecific gravity of different ſubſtances, perfectly intelligible to thoſe who are acquainted with arithmetic no farther than the general rule of proportion :—The certain method of finding whether or not a piece of coin be *current gold*, is ſhewn merely by *weighing*, without any calculation ; and its quality and value may be immediately ſeen by the inſpection of a table calculated for the purpoſe.

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ERRATA.

Page 9, line 13, *for* 4800 *read* 480.
——— line 15, *for* 351 *read* 35, 1.

THE

THE USE OF THE HYDROSTATIC BALANCE,

In determining the quality of GOLD, *&c.*

THE principal and diſtinguiſhing qualities of pure GOLD are the ſimplicity, minuteneſs, and cloſe coheſion of its parts; whereby a greater number of thoſe parts is contained in leſs ſpace than of any other body that we know of.

As all bodies weigh in proportion to their quantity of matter, the ſpecific weight of Gold muſt therefore be ſuperior to that of all other metals.

It follows from hence, that if Gold be adulterated with any other metal, its *ſpecific gravity*, or comparative weight, muſt be *leſs* in proportion to the quantity of *Alloy*: Therefore the *weight* of Gold is a ſure criterion of its quality.

In order to determine the precife quantity of Alloy compounded with Gold, the Gold muft be weighed with fome other mafs as a *ftandard*, and their relative gravities computed.

For this purpofe it is neceffary that the ftandard fhould be of one fixed and determinate gravity, and liable in the fmalleft degree to variation. *Fluids* are, by far, the moft convenient, and *pure rain water** the leaft objectible of any other.

From various hydroftatical experiments, it is found, that when any fubftance is immerfed in a fluid fpecifically lighter than itfelf, it lofes as much of its own weight, as is equal to the weight of a quantity of the fluid, of the fame bulk as the fubftance weighed in it; and the fluid gains as much weight as the body weighed in it lofes.

Hence it is extremely eafy to compute the fpecific gravity of gold, or any other metal, by means of an accurate Hydrostatic Balance; and thereby immediately determine its quality and real value.

If a piece of gold be firft weighed in air, in the ufual manner, and its precife weight, in grains, remarked;

* *Rain Water* is generally preferable, but, as this is feldom to be obtained perfectly pure, clear fpring Water will anfwer the purpofe nearly as well.

marked; when it is afterwards weighed in water, it will be found to weigh confiderably lefs. If its weight in water be fubftracted from what it weighed in air, the difference will fhew the *lofs* it has fuftained by being weighed in a denfer medium: The *weight in air* being then divided by the *lofs in water*, the quotient fhews the *fpecific gravity*, or how many times gold is heavier than water.

On the contrary, the fpecific gravity of *fterling gold* being known, if the *weight in air* of any piece of gold coin, be divided by the *fpecific gravity* of fterling gold, the quotient fhews what ought to be its *lofs* when weighed in water, and if it be found to lofe more, the gold is bad, or has too great a quantity of alloy.

Gold is about 18 times as heavy as common water; the fpecific gravity of fterling gold being to the weight of water, as 17,793 to 1; if therefore a Guinea weighs in air 129 grains, when weighed in water it muft lofe 7,25, or $7\frac{1}{4}$ grains of its weight, becaufe 7,250 : 129 :: 1 : 17,793; —fo that a quantity of water, equal in bulk to a fterling guinea weighs $7\frac{1}{4}$ grains.

The method of computing *in what proportion* the quantity of alloy in counterfeit gold exceeds that which is allowed to *ftandard*, (which is 22 Carats of fine gold § to 1 of filver, and 1 of copper) will

§ The Specific Gravity of which is nearly about 19.15.

will be mentioned hereafter;—I ſhall firſt deſcribe the HYDROSTATIC BALANCE, and the method of applying it to uſe.

Of the HYDROSTATIC BALANCE.

THE BEAM of this Balance ought to be at leaſt eight inches in length, but, for accurate experiments, one of ten inches is preferable; made of tempered ſteel, the ſlenderer the better, ſo that it may turn with the lighteſt weight, and balanced on its center in ſuch a manner as to vibrate very ſlowly. It ſhould be made to reſt on a ſtand; a *pendant* beam being not only inconvenient for the purpoſe, but is liable to various inaccuracies.

To the BEAM is adjuſted a pair of ſcale-pans, which may be taken off at pleaſure; there is alſo another ſmaller pan of equal weight with one of the others, furniſhed with ſhorter ſtrings, ſo as to admit a veſſel of water to be placed under it. When the balance is uſed for hydroſtatic purpoſes, this pan is to be ſuſpended at one end of the beam, and one of the common ſcale-pans at the other.

The glaſs BUCKET is to hold any ſolid body intended to be weighed in water, and is to be ſuſpended by the horſe-chair, to the hook at the bottom of the ſmall ſcale; there is a weight to be placed in the oppoſite ſcale, in order to balance the bucket exactly in water.

The

The braſs Tongs are likewiſe for the ſame purpoſe, and to hold ſuch ſubſtances as cannot conveniently be put into the bucket.

The ſmall braſs Nipper is intended for the weighing of Gold coin; which may be much more accurately weighed in this, than in the *Bucket*; which, indeed, is deſigned to be uſed only for ſuch ſubſtances as cannot well be placed in the *Nipper* or *Tongs*;——the beam will turn much eaſier with either of theſe, than with the other.----A ſcale-beam, loaded at each end with a conſiderable weight, is inſenſible of the addition of a ſmall one; beſides, the reſiſting medium of water, through which the whole ſurface of the bucket and its contents muſt paſs, prevents the vibration of the beam, and renders the operation both tedious and uncertain.

The glaſs Solid is made uſe of in determining the ſpecific gravity of Fluids.

N. B. Each of theſe Appendages has its reſpective Weight for a *balance in water*, diſtinguiſhed by different marks.——Theſe weights are intended to balance them *exactly*; but they may not always be correct; water varies conſiderably in its denſity, according to the temperature of the air; in hot weather it is lighter, in cold heavier; in the former caſe the balance-weight may appear rather

too

too light, and in very cold weather too heavy. Whenever this happens, the equilibrium muſt be reſtored by the addition of a ſmall weight, dropt into the Scale that requires it, before any hydroſtatic experiments can be performed with accuracy. ——From hence it is natural to conclude, that the ſpecific gravity of the ſame ſubſtances will be different at different times; this variation however, is ſo ſmall, particularly in the weight of gold, as not to be regarded in common experiments.

In order to find the preciſe ſpecific gravity of any ſubſtance, it will generally be requiſite to compute the *decimal parts* of a grain; the better method therefore, of weighing, is by *tenths* of a grain, rather than by eighths, ſixteenths, &c.—for which purpoſe, I have divided the grains by *decimals*, viz. into 1, 2, 3, 4, and 5 tenths, which, in the calculation, may be termed 5, 50, 500, &c. as the caſe requires.

Method of finding the Specific Gravity *of* Solids.

Let the Subſtance be firſt accurately weighed in air, ſetting down with a pen the weight in grains and decimal parts; then hang on the ſmall water-ſcale to one end of the beam, and place under it the glaſs veſſel, pouring in water till it is filled within about three quarters of an inch from the brim: Let the body to be weighed be then placed in

in the Nipper, Tongs, or Bucket, as is moſt convenient: and, immerging it in the water, let it be ſuſpended by the horſe-hair, to the hook at the bottom of the water-ſcale:—Obſerve that the ſame weights which balanced the body in air, are in the oppoſite ſcale, and likewiſe the proper *balance-weight:* Care alſo muſt be taken that no *air-bubbles* adhere to any part of the ſubſtance in the water, which will render it apparently lighter. The oppoſite ſcale to that which contains the ſubſtance, will now greatly preponderate; weights muſt therefore be taken out of it, or rather, (which will be found much more convenient) weights muſt be put into the *water-ſcale*, till the equilibrium be exactly reſtored. The pen and ink then finiſh the operation—divide the *weight in air*, by the *loſs in water*, that is, divide the number of grains in the large ſcale, by thoſe in the ſmall one, and the quotient will ſhew the ſpecific gravity, or how many times heavier the ſubſtance that was weighed is than water. If the weight in the ſmall ſcale be *ſubſtracted* from that in the other, it will ſhew the *reſpective gravity* of the weighed ſubſtance, or the weight with which it will be evenly balanced in water.———An example or two will render this ſtill more plain.

Example I.

Let a new ſterling Guinea be weighed in air, and it will be found to weigh full 129 grains; fix it

it in the *nipper* fuſpending from the water-ſcale, and immerge it in the water (the balance-weight of the nipper being in the oppoſite ſcale) it will then appear to be lighter, but if 7¼ grains are put into the water-ſcale, the equilibrium will be reſtored, which ſhews that the guinea is good, or that ſterling gold is 17,793 times as heavy as water, for ſo the ſpecific gravity will turn out.—Again,

EXAMP. 2.

Suppoſe a Guinea is ſuſpected to be bad or counterfeit gold; tho' upon weighing it in air it is found to be of its full weight, or 129 grains,‖ yet if, after weighing it in water, it is found to loſe more than 7,25 (ſuppoſe 8,12) what is its ſpecific gravity?

As the loſs in water is to the weight in air, ſo is 1 *to the ſpecific gravity*; therefore 8,12 : 129 : : 1 : 15,886. ſo that 129,00 divided by 8,12 gives 15,886 for the ſpecific gravity, which ſhews that the gold is much worſe than ſterling.

EXAMP. 3.

If a piece of ſilver weighs 636 grains in air, what is the ſpecific gravity, ſuppoſing it to loſe 60,7 when

‖ This is *nearly* the weight of a new Guinea, but not ſtrictly ſo—its real weight (valuing Gold at £ 3 17 10½ per Ounce) is 129,438, or nearly 5dwts. 9½ grains: The loſs in water will therefore be 7,27.

when weighed in water? 60,7 : 636 : : 1 : 10,478 the ſpecific gravity; by which it appears to be good ſilver.

EXAMP. 4.

How much heavier than water is Flint-Glaſs? A piece of white flint-glaſs weighed 169,05; and loſt 50,60

50,60 : 169,05 : : 1 : 3,341

ſo that it was ſomewhat more than $3\frac{1}{3}$ times heavier than its bulk of water.

EXAMP. 5.

Mercury, tho' properly a fluid, is to be weighed as a ſolid; thus, put 1 ounce, or 4800 grains of Mercury into the glaſs Bucket, and weighing it in water, it will be found to loſe nearly about 351 grains; Mercury therefore is heavier than water as 13,67 to 1.

The method is the ſame for moſt other ſolid ſubſtances that are ſpecifically *heavier* than water: for thoſe that are *lighter*, the proceſs is ſomewhat different.

When any thing floats on the ſurface of a fluid, it diſplaces juſt ſo much of the fluid as is equal in weight to the weight of the whole floating body. Suppoſe a hollow cube of tin, 2 inches ſquare, to

weigh 1 ounce; this being floated on water may be ſuppoſed to ſink in it half an inch, or one fourth part of the whole: If ſo, a body of water 2 inches ſquare, and half an inch thick, muſt weigh 1 ounce, equal to the weight of the cube, which would be 4 times ſpecifically lighter than water. The cube would require an additional weight of 3 ounces to immerge it totally in the fluid; the *reſpective* gravity of the water, to the cube, is therefore as 3 to 1, and conſequently a bulk of water equal to the cube, would weigh 4 ounces.

From hence, the method of weighing light ſubſtances ſpecifically, is as eaſily conceived and put in practice, as that of weighing the heavier ones. Tho' ſeveral different appendages have been made to the hydroſtatic balance for this purpoſe, they appear in general to be unneceſſary, as moſt ſubſtances that are not too large to go into the braſs Tongs, may very accurately be weighed in it.

EXAMP. 6.

Suppoſe it was required to find the ſpecific gravity of a piece of dry *beech-wood*, weighing 59,50 gaains.

Having ſet down the weight of the wood in air, fix it in the Tongs, and ſuſpend the whole to the water-ſcale, placing the balance-weight of the

tongs

tongs in the oppofite fcale.—In the foregoing experiments, we let the weights with which the fubftance was weighed, *remain in the fcale*,—— we are now to *take out* all of them, except the *balance-weight*; and, upon immerging the tongs and wood into the water, they will appear to be *lighter* than the tongs alone. That adding a weight to one end of a fcale-beam, fhould make the other end preponderate, feems to be as *paradoxical* as the *weighing of levity*; but it ceafes to be fo when we confider that no bodies afcend by means of their *levity*, but by reafon of the greater denfity of the medium in which they are immerfed. The wood pulls the tongs upward with a force equal to the *refpective gravity* of the water, fo that it requires as much weight to reftore the equilibrium, as the wood is lighter than its bulk of water. Small weights are therefore to be put into the water-fcale, till the balance be even; and *the weight of the wood in air*, added to thefe fmall weights, will be *equal to the weight of a bulk of water* of the fame fize as the wood;—confequently the *fpecific gravity* will be *as the weight of fuch a bulk of water* is to the *weight of the wood in air*.

When I weighed the wood, I put 16,70 grains into the water-fcale, before the balance became even. 16,70 added to 59,50 (the weight of the wood) make 76,20, therefore

76,20 : 59,50 : : 1,000* : ,781 the ſpecific gravity of the Beech.

EXAMP. 7.

A piece of very dry *Cork*, weighing in air 24,3 grains, required 149,2 to be put in the water-ſcale, to reſtore the balance.——149,2 added to 24,3 make 173,5 (the weight of a bulk of water equal to the cork.)—As 173,5 : 24,3 : : 1,000 : ,152 the ſpecific gravity of the cork ;—7 times lighter than water.

The ſpecific gravity of another piece of cork was ,241, or about 4 times lighter than water.

N. B. In weighing of thoſe bodies whoſe pores readily imbibe the water, the quicker the experiment is performed, the more likely it is to be correct.

Method of finding the SPECIFIC GRAVITY *of* FLUIDS.

That which is meant by the term *ſpecific gravity* of bodies, being nothing more than the difference, or comparative weight of thoſe bodies to that of common water, we might eaſily find the ſpecific gravity

* In hydroſtatic calculation, water, as the ſtandard from which all the reſpective gravities are taken, is reckoned as unity or 1, 10, 100, 1000, &c. as the caſe requires.

gravity of any kind of *fluid*, by weighing a quantity of it againſt an equal quantity of water; but, as a *ſolid* body, when immerſed in a fluid, loſes as much of its weight as a bulk of the fluid equal to the body weighs, a more convenient and accurate method, is the immerſion of a *ſolid*, of ſome determinate weight, in the fluid whoſe ſpecific gravity we deſire to know.

For this purpoſe is the conical piece of *ſolid glaſs*, belonging to the hydroſtatic balance; whoſe weight, both in air and in water, being known, ſhews immediately the weight of the fluid into which it is ſuſpended; the ſolid being borne up by the fluid in a proportion equal to its reſpective gravity.

Suppoſe the glaſs ſolid to weigh in air 1464 grains; and that, when it is ſuſpended from the water-ſcale, and immerged in water, it loſes of its weight 445 grains; this would be the weight of a bulk of water equal to the ſolid. The balance-weight for the ſolid muſt be made juſt equal to what it weighs in water, i. e. 1019 grains.

Whatever fluid is to be weighed, let it be put into the glaſs recipient;—ſuſpend the ſolid to the hook of the water-ſcale, and let it hang freely in the liquor, putting the balance-weight in the oppoſite ſcale.—If the fluid be heavier than water, the ſolid will riſe in it,—if lighter, it will ſink to the

the bottom of the recipient. In either cafe fmall weights are to be put into the lighter fcale, till the balance be made even.

1. When the fluid is *lighter* than water, the weight *gained* by the glafs folid is to be *fubftracted* from the weight of a bulk of water equal to the folid, [445] and the remainder is the weight of an equal bulk of the fluid, or its fpecific gravity to water.

EXAMP. 1.

When fuch a glafs folid as the above was immerfed in *Brandy*, it balanced 38,2 grains more than in water; this taken from 445,0, leaves 406,8; therefore the fpecific weight of the brandy was to water as 406,8 to 445.

To reduce it to its proper terms——multiply the difference [38,2] by 1000, (the denominator of water) and divide the product by 445;——As 445 : 38,2 : : 1000 : 86———Subftract 86 from 1000, there remain ,914 the fpecific gravity of the brandy.

From hence it appears, that the brandy weighed 86 parts in 1000, or about $\frac{1}{12}$ lefs than water.

EXAMP. 2.

In *Rum*, the ſolid balanced 40,3 grains more than in water,——As 445 : 40,3 :: 1000 : 91 —91 from 1000, remain 909.————The ſpecific gravity of the rum to water was therefore ,909—or about $\frac{1}{11}$.

EXAMP. 3.

When the ſolid was immerſed in highly rectified *ſpirit of wine*, it balanced 73,6 more than in water; therefore 445 : 73,6 :: 1000 : 165 —165 from 1000, remain ,835, or $\frac{1}{6}$.

It appears from theſe examples, that the *Hydroſtatic Balance* is a moſt certain and correct inſtrument for determining the *ſtrength of ſpirits*; perhaps more ſo than the moſt accurate *Hydrometer* that has yet been made for that purpoſe.

It is of conſiderable conſequence to diſtillers, and dealers in ſpirituous liquors, to know the preciſe point of ſtrength which is termed *proof*: Though this, indeed, is rather arbitrary than any fixed ſtandard; but the degree of ſtrength, which, I am informed, is now called merchantable *proof*, fixeth the ſpecific gravity of the ſpirit to water at ,930.

930 taken from 1000, leaves 70, therefore 1000 : 70 :: 445 : 31,15. So that in *proof ſpirit*,

rit, a glaſs ſolid of the weight above-mentioned, muſt balance 31,15 or about $31\frac{1}{4}$ grains more than in water.

It may eaſily be found in what proportion the ſpirit is *above* or *below* proof, by obſerving what quantity of *water* or *alchohol* is neceſſary to be mixed with it, in order to bring it to the above ſtandard; and it might be immediately known, by comparing the weight of the ſpirit with that of water, if the ſpecific gravity of both, when compounded, remained in the ſame ratio as when ſeparate: But, as it is found that, when water is mixed with ſpirit, the ſpecific gravity of the compound is *greater* than that of the water and the ſpirit before they are compounded, the calculation muſt therefore turn out incorrect,—for inſtance,

A quantity of the *rum*, before-mentioned, equal in bulk to the glaſs ſolid, weighed very nearly 405 grains—an equal bulk of water, 445 grains;——ſuppoſe then, that in order to reduce the rum to *proof*, one *fifth part* of water was to be mixed with it;

Water	-	1	=	445
Rum	-	4	=	1620
		5)		2065
Mean weight			=	413

By

By this it appears that a quantity of the compound, equal in bulk to the glaſs ſolid, ſhould weigh, 413 grains, and conſequently that the ſolid, when immerſed in it, ſhould balance 32 grains more than in water; in which caſe it would ſtill be ſomewhat above proof.

But, upon trial, it will be found to balance not much more than $29\frac{1}{2}$, and that there muſt be but little more than *one ſeventh* part of water mixed with the rum to reduce it to the given ſtandard.

Immediately after water is mixed with ſpirit, the compound appears *lighter*; but in a few hours afterwards, when the particles of each are more intimately united, its bulk diminiſhes, and conſequently the ſpecific gravity increaſes.

From a few experiments of this kind, the theory will appear ſufficiently plain; and a table might eaſily be formed for ſhewing by inſpection what quantity of water is neceſſary to be put to any given quantity of ſpirit, to render it true proof; but, as this is rather a deviation from my preſent deſign, I ſhall refer the reader to a tract publiſhed by Mr. B. Martin, in *Fleet-ſtreet*, intitled, *The Theory of the genuine Hydrometer illuſtrated*, in which the principles of this part of hydroſtatics are explained, and the great uncertainty and imperfection of the common *Hydrometer* pointed out.

2. When fluids are ſpecifically *heavier* than water, the glaſs ſolid, as before obſerved, will *riſe* in ſuch fluid, (the water balance-weight being in the oppoſite ſcale,) and appear to be lighter; ſmall weights are therefore to be put in the water-ſcale, till the equilibrium be reſtored; and the *loſs* which the ſolid ſuſtains by being weighed in the heavy fluid, is to be *added* to the weight of a bulk of water equal to the ſolid—the ſum ſhews the ſpecific gravity of the fluid to water.

EXAMP. 4.

Suppoſe it was required to find the ſpecific gravity of *ſea-water*, or how much heavier it is than rain-water.

Let the ſolid be ſuſpended, as uſual, to the water-ſcale, and immerſed in the ſea-water; putting the balance-weight in the oppoſite ſcale. It will require 11,6 grains to bring it to an even balance.

As 445 : 11,6 : : 1000 : 26.

The ſpecific gravity is therefore 1026; which ſhews that Sea-water is 26 parts in 1000, or $\frac{1}{38}$ heavier than Rain-water; or that there muſt be 1026 meaſures of Rain-water, to weigh as much as 1000 meaſures of Sea-water.——The method is the ſame for every other fluid ſpecifically heavier than water.

The

The ſpecific gravity of *ſalt* and *water*, in equal quantities (in meaſure) is 1205; or, about $\frac{1}{5}$ heavier than common water.

Method of diſcovering the Proportion of ALLOY *mixed with* GOLD.

The ſpecific gravity of *ſterling* or *money* gold, as before obſerved, is 17,79, which is the ſtandard made uſe of in the following calculations, as it comes the neareſt to the average weight of the current Britiſh coin. The ſpecific gravity of pure or very fine gold is, indeed, conſiderably more; in ſome tables it is made 19,64, but I never met with any ſo heavy as this. The ſpecific gravity of good *ſilver* is 10,37. Of *copper* 8,83.

If then, a maſs be compounded of *gold* and *ſilver*, the ſpecific gravity of the compound may be thus found, without the uſe of the balance.

EXAMP. I.

Suppoſe a maſs of metal, half *gold* and half *ſilver*, [in weight] to weigh in air 258,8 grains, what muſt be the ſpecific gravity of this compound, to an equal bulk of water?

RULE—Compute what muſt be the *loſs in water* of the proportional part of each metal, by dividing

 its

its weight in air by its ſpecific gravity: Add the two ſums together, and by this product divide the weight of the whole maſs;——the quotient will ſhew the ſpecific gravity.

	Weight in air.	Loſs in water.
Ratio of the Gold	129,4	7,27
———— Silver	129,4	12,47
	258,8	19,74.

258,8, divided by 19,74 gives 13,11 the ſpecific gravity of the compound maſs.

EXAMP. 2.

If a *Guinea* be adulterated with *copper*, in the proportion of 4,39 *gold*, and 1 *copper*, what is its ſpecific gravity?

Say—If a maſs, weighing 5,39 grains, contains 1 grain of copper, how much will be contained in a maſs weighing 129,4?

As 5,39 : 1 :: 129,4 : 24.

The guinea muſt therefore contain 24 grains of copper, and 105,4 of gold.

Loſs in water of	105,4	grains of gold	= 5,93
————	24,0	———— copper	= 2,71
	129,4		8,64

129,4 divided by 8,64 gives 15 for the ſpecific gravity.

The

The ſame method may be uſed for determining the ſpecific gravity of any other maſs, though compounded of three or more different metals, provided the ratio of each metal be known.

The *reverſe* of theſe examples muſt therefore be the rule for diſcovering the proportion of alloy mixed with gold, after its ſpecific gravity is found by the balance.

EXAMP. I.

What is the proportion of gold and ſilver in a maſs (weighing 258,8 grains) whoſe ſpecific gravity is found to be 13,11 ?

RULE—Compute what muſt be the loſs in water of a maſs of *gold*, of equal weight with the compound, and likewiſe of a maſs of *ſilver*, of the ſame weight; ſubſtract the loſs of gold from that of the compound—the remainder is the ratio of ſilver;—ſubſtract the loſs of the compound from that of ſilver—the remainder is the ratio of gold.

Loſs in water of	258,8	grains of gold	= 14,54
————	258,8	——— ſilver	= 24,94
————	258,8	the compound	= 19,74

14,54 taken from 19,74 there remain 5,20——— 19,74 from 24,94 remain likewiſe 5,20; by which it appears that the weight of the gold and ſilver is in equal proportion—agreeably to the firſt preceding example.

EXAMP.

EXAMP. 2.

If a *guinea*, of its full weight, or 129,4 grains, be adulterated with *copper*, and its loſs in water found to be 8,64, what quantity of copper is mixed with it?

Loſs of 129,4 grains of gold	=	7,27
——— 129,4 ——— copper	=	14,65
——— 129,4 the compound	=	8,64

7,27 from 8,64 remain 1,37——8,64 from 14,65 remain 6,01——ſo that the proportion of the copper is to that of the gold as 1,37 to 6,01; or, (agreeably to the ſecond preceding example) as 1 to 4,39 *i. e.* 24 grains of copper, and 105,4 of gold.

If it be required to find the reſpective *bulk* of each metal in the compound maſs,——Firſt, find its ſpecific gravity, and then ſubſtract the ſpecific gravity of the *inferior* metal from that of the *compound*, and the remainder ſhews the ratio of *gold*; then, if the ſpecific gravity of the *compound* be ſubſtracted from that of the *gold*, the remainder is the ratio of the *inferior* metal.

It muſt be obſerved that, in the preceding examples, the quality of the alloy, with which the gold is compounded, is ſuppoſed to be *known*, together with its ſpecific gravity: But this is ſeldom the caſe—it is not often diſcoverable with what par-

particular metal or metals a counterfeit guinea is adulterated, much lefs their exact *fpecific gravity*, which is neceffary to be known: The foregoing experiments then, may appear to be calculated more for amufement, than for any real utility, in determining the *value* of bad gold. This conclufion, however, would be rather too precipitate,—fuch experiments and calculations have not only a tendency to familiarize the fubject, but they lead directly to the defired point.

Gold may be made to retain a very fpecious appearance, and yet be rendered much worfe than *fterling*, by being adulterated with inferior metals, —*filver*, *copper*, fome kinds of *brafs*, &c. and though the weight of thefe, after the mafs is compounded, cannot be precifely afcertained, nor confequently the exact ratio of the *gold*; yet, by taking the *mean* fpecific gravity of the metals generally ufed for adulterating of gold, and attending to the weight, colour, &c. of the compound, a pretty correct judgment might be formed of the nature of the *alloy*; and if this be *nearly* true, the hydroftatic examination cannot be very erroneous, but will generally prove fufficiently accurate.

As a fterling *guinea*, when weighed in water, is found to lofe 7¼ grains of its weight, if it lofes more than this, the ufual method has been to reckon the gold fo much worfe than fterling, by allowing or deducting from its value, a certain fum for

for every grain that it loſes more than $7\frac{1}{4}$; and perhaps, a more correct method cannot be taken, if that ſum be adequate to the weight of the alloy.

A piece of good *ſilver*, of equal weight with a *guinea*, (or 129,4 grains) when weighed in water, loſes of its weight 12,47 grains, which is 5,2 more than the guinea loſes:

$$\begin{array}{ccccccc} & & \text{pence.} & & & & \text{pence.} \\ 5{,}2 & : & 252 & :: & 1 & : & 48{,}4 \end{array}$$

If therefore a *guinea*, or other piece of gold coin, be adulterated with *ſilver*, *four ſhillings*, at leaſt, muſt be deducted from its value, for every grain that it loſes more than it would loſe were it ſterling gold.

A piece of *copper*, of equal weight with a guinea, loſes in water 14,65, which is 7,38 more than a guinea.

$$\begin{array}{ccccccc} & & \text{pence.} & & & & \text{pence.} \\ 7{,}38 & : & 252 & :: & 1 & : & 34 \end{array}$$

So that, if ſterling gold be adulterated with *copper*, *two ſhillings and ten-pence* is to be deducted from its value for every deficient grain;—and the ſame method will aſcertain the proportion for every other ſpecies of alloy.

Counterfeit guineas are ſeldom found to be adulterated with *ſilver* alone, but more generally with *copper*, with a ſmall quantity of ſilver; or with metals whoſe weight is nearly equal to that of copper.

From

A TABLE *of the proper Loſs in Water of* STERLING GOLD, *the ſpecific Gravity of which being* 17,79; *from* 1 *Grain to* 240.

Weight in Air.	Loſs in Water.	Weight in Air.	Loſs in Water.	Weight in Air.	Loſs in Water.	Weight in Air.	Loſs in Water.	Weight in Air.	Loſs in Water.
1	0,056	49	2,75	97	5,45	145	8,15	193	10,85
2	0,11	50	2,81	98	5,50	146	8,21	194	10,91
3	0,17	51	2,86	99	5,56	147	8,26	195	10,96
4	0,22	52	2,92	100	5,62	148	8,32	196	11,00
5	0,28	53	2,97	101	5,68	149	8,38	197	11,07
6	0,34	54	3,03	102	5,73	150	8,43	198	11,12
7	0,39	55	3,08	103	5,78	151	8,49	199	11,18
8	0,45	56	3,14	104	5,84	152	8,55	200	11,24
9	0,51	57	3,20	105	5,90	153	8,60	201	11,29
10	0,56	58	3,25	106	5,95	154	8,66	202	11,35
11	0,61	59	3,31	107	6,01	155	8,71	203	11,41
12	0,67	60	3,37	108	6,07	156	8,77	204	11,46
13	0,73	61	3,42	109	6,12	157	8,83	205	11,52
14	0,78	62	3,48	110	6,17	158	8,88	206	11,57
15	0,84	63	3,54	111	6,23	159	8,94	207	11,63
16	0,90	64	3,60	112	6,29	160	9,00	208	11,69
17	0,95	65	3,65	113	6,35	161	9,05	209	11,75
18	1,01	66	3,71	114	6,41	162	9,10	210	11,80
19	1,07	67	3,76	115	6,46	163	9,16	211	11,86
20	1,12	68	3,82	116	6,51	164	9,21	212	11,91
21	1,18	69	3,88	117	6,57	165	9,27	213	11,97
22	1,24	70	3,93	118	6,63	166	9,33	214	12,03
23	1,29	71	3,99	119	6,69	167	9,39	215	12,09
24	1,35	72	4,05	120	6,75	168	9,45	216	12,14
25	1,41	73	4,10	121	6,80	169	9,50	217	12,20
26	1,46	74	4,16	122	6,85	170	9,56	218	12,25
27	1,52	75	4,21	123	6,91	171	9,62	219	12,31
28	1,58	76	4,27	124	6,97	172	9,67	220	12,36
29	1,63	77	4,33	125	7,02	173	9,72	221	12,42
30	1,69	78	4,38	126	7,08	174	9,78	222	12,47
31	1,74	79	4,44	127	7,14	175	9,83	223	12,53
32	1,79	80	4,50	128	7,20	176	9,89	224	12,59
33	1,85	81	4,55	129	7,25	177	9,95	225	12,65
34	1,91	82	4,60	130	7,31	178	10,00	226	12,70
35	1,96	83	4,66	131	7,36	179	10,06	227	12,76
36	2,02	84	4,72	132	7,41	180	10,12	228	12,81
37	2,08	85	4,78	133	7,47	181	10,17	229	12,87
38	2,13	86	4,83	134	7,53	182	10,23	230	12,92
39	2,19	87	4,89	135	7,58	183	10,28	231	12,97
40	2,25	88	4,94	136	7,64	184	10,34	232	13,02
41	2,30	89	5,00	137	7,70	185	10,40	233	13,08
42	2,35	90	5,06	138	7,75	186	10,45	234	13,14
43	2,41	91	5,11	139	7,81	187	10,51	235	13,20
44	2,47	92	5,17	140	7,87	188	10,57	236	13,26
45	2,52	93	5,23	141	7,92	189	10,62	237	13,32
46	2,58	94	5,28	142	7,98	190	10,68	238	13,38
47	2,64	95	5,34	143	8,04	191	10,74	239	13,44
48	2,69	96	5,39	144	8,09	192	10,79	240	13,49

TABLE of DECIMAL PARTS of a GRAIN, at Three Shillings.

	s.	d.		s.	d.		s.	d.		s.	d.		s.	d.
1	0	3½ ,4	3	0	10¾ ,2	5	1	6	7	2	1 ,8	9	2	8¼ ,6
2	0	7 ,8	4	1	2¼ ,6	6	1	9½ ,4	8	2	4¾ ,2	10	3	0

From the mean weight of these metals, compared with different *assays* that have been made of counterfeit gold, it appears that, if *three shillings* be allowed for every grain deficient in the specific gravity, it will come nearer to the truth than any other sum, and may generally be relied on as sufficiently correct.

To prevent any error, or loss of time in calculation, I have annexed a table of the proper loss of *sterling gold*, when weighed in water, by the inspection of which (and the small table of *decimals*) it may be immediately seen how much almost any piece of gold coin is worse than sterling.

The use of these tables is obvious—for instance, suppose it was required to know the quantity of gold, or the value of a bad *guinea*, weighing in air 128 grains, (which is pretty nearly the weight that most counterfeit guineas are made) and whose loss in water is 8 grains:—By the table it appears that 128 grains of sterling gold ought to lose in water 7,20 grains. 7,2 taken from 8, leaves ,8 ——and by the table of decimals it appears that 8 tenths of a grain deficient is $=2s.\ 4d\frac{3}{4}$, and so much is the gold worse than sterling. The value of the guinea, then, (allowing $2d.\ \frac{3}{4}$ for the deficiency of its proper weight) is $18s.\ 4d.\ \frac{1}{2}$.

Though this method of determining the *value* of gold may not always be *precisely correct*, it never

can vary from the truth in any great degree, but will always be found ſufficiently near for common purpoſes; and merely to find whether or not a piece of coin be *current gold*, the method before directed is not liable to error, but, with ſuch a balance as hath been deſcribed, may be known to abſolute certainty. The only neceſſary precaution is to mind that the water be freſh,* ſo that the balance-weights may produce a due equilibrium: The *guinea* being then evenly balanced, firſt in air, and afterwards in water, if it loſes no more than $7\frac{1}{4}$ grains, it is good or ſterling gold; but if it is found to loſe half a grain more, it has too much alloy to be current.

The Hydrostatic Balance being in itſelf ſo ſimple an inſtrument, and the method of applying it to uſe, in detecting bad money, ſo extremely eaſy and certain, it ſeems rather to be wondered at that it is not at this time in general uſe; when every perſon finds himſelf liable to be daily deceived by light or counterfeit coin; The principal reaſon, perhaps is, that the beſt balances are ſeldom ſold without an apparatus of different appendages, which has not only enhanced the price double to what they might be rendered for, but has likewiſe made the method of applying it to uſe, appear complex and troubleſome; and the common inſtruments, in the form of *ſteelyards*, &c. pretendedly

* If the water be *warm*, it will be lighter, and conſequently the gold appear heavier than it really is.

edly made for *hydroſtatic balances*, are found to be quite inadequate to the purpoſe, and—in ſhort, worſe than nothing. All that is neceſſary for readily detecting of counterfeit coin, is a good ſcale-beam on a convenient ſtand, with a hook to one of the pans for ſuſpending a pair of ſmall nippers—and a glaſs of water. Theſe might always be ready at hand for occaſional uſe—always depended upon—and but little more time taken up in the operation than weighing in the common manner.

It may ſometimes be of uſe to know what quantity of pure or *fine gold* is contained in a given maſs;—this may eaſily be found by the preceding rules, if, inſtead of dividing by the ſpecific gravity of *ſterling gold*, we make uſe of that of *fine gold*, which is nearly about 19,15 or 19,20:—for example,

What quantity of fine gold is contained in a *gold ring*, adulterated with *ſilver*, weighing 64,5 grains, and whoſe ſpecific gravity is 15,89?

Proceed as before directed (page 21) and the ratio will ſtand thus,

Loſs in water of	64,5	grains of fine Gold	= 3,37
———	64,5	——— Silver	= 6,23
———	64,5	——— the Ring	= 4,06

3,37 taken from 4,06 there remain 0,69——4,06 from 6,23 remain 2,17; ſo that the weight

 of

of the gold is to that of the ſilver as 2,17 to 0,69 or as 3,14 to 1.

22 Carats of *fine gold*, whoſe ſpecific gravity amounts to 19,15, will admit of 1 carat of *ſilver*, and 1 of *copper*, to reduce it to *ſterling*, or the ſpecific gravity of 17,79; therefore, if ſterling gold be valued at £3 : 17 : 10 per ounce, the gold whoſe pecific gravity is 19,15 is worth £4 : 4 : 11 an ounce, or 7 ſhillings more than ſterling gold.

As it will frequently be neceſſary for thoſe who are concerned in buying or refining of gold, to know the value of different quantities, at different prices per ounce; to ſuch as are not poſſeſſed of Mr. Etheridge's Gold Tables, which are by far the beſt that I have ſeen, the following will be of uſe.

Ta-

Table of the Value of GOLD,

At £ 3 : 17 : 0 per Ounce.

Grains.

gr.	£.	s.	d.	q.
1	—	—	1	3
2	—	—	3	3
3	—	—	5	3
4	—	—	7	2
5	—	—	9	2
6	—	—	11	2
7	—	1	1	1
8	—	1	3	1
9	—	1	9	1
10	—	1	7	1
11	—	1	9	
12	—	1	11	
13	—	2	1	
14	—	2	2	3
15	—	2	4	3
16	—	2	6	3
17	—	2	8	2
18	—	2	10	2
19	—	3	—	2
20	—	3	2	2
21	—	3	4	1
22	—	3	6	1
23	—	3	8	1

Pennyweights.

dw	£.	s.	d.	q.
1	—	3	10	
2	—	7	8	1
3	—	11	6	2
4	—	15	4	3
5	—	19	3	
6	1	3	1	
7	1	6	11	1
8	1	10	9	2
9	1	14	7	3
10	1	18	6	
11	2	2	4	
12	2	6	2	1
13	2	10	—	2
14	2	13	10	3
15	2	17	9	
16	3	1	7	
17	3	5	5	1
18	3	9	3	2
19	3	13	1	3

Ounces.

oz.	£.	s.	d.
1	3	17	—
2	7	14	—
3	11	11	—
4	15	8	—
5	19	5	—
6	23	2	—
7	26	19	—
8	30	16	—
9	34	13	—
10	38	10	—
11	42	7	—

Pounds.

lb.	£.	s.	d.
1	46	4	—
2	92	8	—
3	138	12	—
4	184	16	—
5	231	—	—
6	277	4	—
7	323	8	—
8	369	12	—
9	415	16	—
10	462	—	—

I have chosen the sum of £ 3 : 17 : 0 per ounce for Gold, as a *mean* of its fluctuating value; if it be *more* or *less* than this, the value of any quantity, at any price, may be easily found by the table, in the following manner,—first set down the value of the required quantity of gold at £ 3 : 17 : 0 per ounce by the table; then, if it be valued at *more, for as many* PENCE *as the value exceeds* £3 : 17 : 0 *add to the sum after the rate of* ONE PENNY *per ounce.* ———Suppose it be required to know the value of 5 *oz.* 5 *dw.* 16 *gr.* of gold, at £ 3 : 18 : 3 per ounce.

	£.	s.	d.
By the table, the value of 5 ounces is	19	5	0
————————5 pennyweights	0	19	3
———————— 16 grains	0	2	$6\frac{3}{4}$
But £ 3 : 18 : 3 is 15 pence more than £3 : 17 : 0, therefore, for the 5 ounces, add 5 times 15 pence, or - - -	0	6	3
5 dwts is $\frac{1}{4}$ of an ounce, for which add 15 farthings or - - - - - -	0	0	$3\frac{3}{4}$
The proportional part of the 16 grains need not be regarded, as it scarcely amounts to an halfpenny.			
The value of the gold is therefore -	20	13	$4\frac{1}{2}$

What

What is the value of 2*lb.* 3*oz.* 8*dw.* of gold, at £ 3 : 17 : 10 per ounce?

		£.	s.	d.
2*lb.*	(at £ 3 : 17 : 0) is	92	8	0
3*oz.*	- - - - - -	11	11	0
8*dwts.*	- - - - -	1	10	9½
For the 2*lb.* add 24 times 10 pence, or		1	0	0
For the 3*oz.* ——3 times 10 pence, or		0	2	6
For the 8*dwts.*	- - - -	0	0	4
Value of the gold, at £ 3 : 17 : 10,		106	12	7½

If the gold be valued at *less* than £ 3 : 17 : 0, the same method may be used, only instead of *adding*, *substract* after the rate of *one penny* per ounce, for as many pence as the value of the gold is under £ 3 : 17 : 0.———For example, what is the value of 1*lb.* 9*oz.* 2*dwt.* 6*gr.* of gold, at £ 3 : 16 : 2 per ounce?

		£.	s.	d.
1*lb.*	(at £ 3 : 17 : 0) is	46	4	0
9*oz*	- - - - - -	34	13	0
2*dwts.*	- - - - - -	0	7	8¼
6*gr.*	- - - - - -	0	0	11½
Value of the gold, at £ 3 : 17 : 0,		81	5	7¾

For 1*lb.* 9*oz.* substract 21 times 10 pence, or	0	17	6	0	17	7
For 2*dwts.* - -	0	0	1			
Value of the gold, at £ 3 : 16 : 2,				80	8	0¾

Table

Table of the Value of SILVER,

At 5 *Shillings* per Ounce.

Grains.

gr.	£.	*s.*	*d.*	*q.*
1	—	—	—	0,5
2	—	—	—	1
3	—	—	—	1
4	—	—	—	2
5	—	—	—	2
6	—	—	—	3
7	—	—	—	3
8	—	—	1	
9	—	—	1	
10	—	—	1	1
11	—	—	1	1
12	—	—	1	2
13	—	—	1	2
14	—	—	1	3
15	—	—	1	3
16	—	—	2	
17	—	—	2	
18	—	—	2	1
19	—	—	2	1
20	—	—	2	2
21	—	—	2	2
22	—	—	2	3
23	—	—	2	3

Pennyweights.

dw	£.	*s.*	*d.*
1	—	—	3
2	—	—	6
3	—	—	9
4	—	1	—
5	—	1	3
6	—	1	6
7	—	1	9
8	—	2	—
9	—	2	3
10	—	2	6
11	—	2	9
12	—	3	—
13	—	3	3
14	—	3	6
15	—	3	9
16	—	4	—
17	—	4	3
18	—	4	6
19	—	4	9

Ounces.

oz.	£.	*s.*	*d.*
1	—	5	—
2	—	10	—
3	—	15	—
4	1	—	—
5	1	5	—
6	1	10	—
7	1	15	—
8	2	—	—
9	2	5	—
10	2	10	—
11	2	15	—

Pounds.

lb.	£.	*s.*	*d.*
1	3	—	—
2	6	—	—
3	9	—	—
4	12	—	—
5	15	—	—
6	18	—	—
7	21	—	—
8	24	—	—
9	27	—	—
10	30	—	—

The

The value of any quantity of Silver, at any price, may be known by this table, in the ſame manner as that for Gold, viz. by *adding* or *ſubſtracting* after the rate of *one penny* per ounce, for as many pence as the value of the ſilver is *more* or *leſs* than *five ſhillings*.

What is the Value of 1*lb.* 4*oz.* 12*gr.* of ſilver, at 5*s.* 5*d.* per ounce?

	£.	s.	d.
By the table, 1*lb.* at 5*s.* per ounce, is	3	0	0
4*oz.* - - -	1	0	0
12*gr.* - - -	0	0	1½
The required value being 5*d.* an ounce more,			
For the 1*lb.* add 12 times 5 pence, or	0	5	0
For 4*oz.* - - - - -	0	1	8
Value of the ſilver, at 5*s.* 5*d.* per *oz.*	4	6	9½

If the value of the Silver be *leſs* than 5 ſhillings, *ſubſtract* as before.

THE STANDARD Pound Weight of SILVER is 11*oz.* 2*dw.* of fine *ſilver*, and 18*dw.* of *copper*. The *ſpecific gravity* of ſuch fine ſilver muſt therefore be 10,52; becauſe 222 pennyweights of ſilver of that gravity, and 18 pennyweights of copper, of 8,83, will produce 1 pound of *ſterling ſilver*, or a compound whoſe ſpecific gravity is 10,37.

Table of the Value of Gold,

At the present Price allowed by the Bank of *England*, viz. 3*l.* 17*s.* 10*d.* $\frac{1}{2}$ per Ounce.

Grains.

gr.	s.	d.	q.
1	—	1	3,787
2	—	3	3,575
3	—	5	3,362
4	—	7	3,150
5	—	9	2,937
6	—	11	2,725
7	1	1	2,512
8	1	3	2,300
9	1	5	2,087
10	1	7	1,875
11	1	9	1,662
12	1	11	1,450
13	2	1	1,237
14	2	3	1,025
15	2	5	—,812
16	2	7	—,600
17	2	9	—,387
18	2	11	—,175
19	3	—	3,962
20	3	2	3,750
21	3	4	3,537
22	3	6	3,325
23	3	8	3,112

Pennyweights.

dw	£.	s.	d.	q.
1	—	3	10	2,9
2	—	7	9	1,8
3	—	11	8	—,7
4	—	15	6	3,6
5	—	19	5	2,5
6	1	3	4	1,4
7	1	7	3	—,3
8	1	11	1	3,2
9	1	15	—	2,1
10	1	18	11	1—
11	2	2	9	3,9
12	2	6	8	2,8
13	2	10	7	1,7
14	2	14	6	—,6
15	2	18	4	3,5
16	3	2	3	2,4
17	3	6	2	1,3
18	3	10	1	—,2
19	3	13	11	3,1

Ounces.

oz.	£.	s.	d.	q.
1	3	17	10	2
2	7	15	9	—
3	11	13	7	2
4	15	11	6	—
5	19	9	4	2
6	23	7	3	—
7	27	5	1	2
8	31	3	—	—
9	35	—	10	2
10	38	18	9	
11	42	16	7	2

lb.	£.	s.	d.
1	46	14	6
2	93	9	—
3	140	3	6
4	186	18	—
5	233	12	6
6	280	7	—
7	327	1	6
8	373	16	—
9	420	10	6
10	467	5	—

As I have, at different times, taken the precife fpecific gravity of a great number of various pieces of Englifh Coin, with a view of afcertaining the quality of the Metal; it may at leaft be entertaining, if not ufeful, to fome perfons, to fee the variation in the *intrinfic value* of the Specie iffued in different Reigns: I intended, indeed, to have arranged thefe in a comparative view with different *foreign coins*, but have not yet collected a fufficient quantity.

I have frequently found a confiderable difference in the hydroftatic weight of the current coin of the fame *reign*, and fometimes in that of the fame year's coinage. This difference may be merely accidental. A piece of metal that has been forcibly *hammered*, will have a greater fpecific gravity than the fame metal only *caft*. The different force, therefore, that is ufed in laminating, or even the impreffion of the mill, may produce fome variation in the fpecific weight of different pieces of coin, made from the fame metal. It is evident then, that weighing a few fingle pieces of coin in the hydroftatic balance, is by no means fufficient to determine the relative value of a coinage; but if a fufficient number be weighed, and the average of the whole computed, the refult will be much more conclufive. In the following tables I have generally taken the mean weight of feveral pieces, weighed both feparately and together.

COPPER coined in the reign of

	Mean Specific Gravity.
George I. - - - - - - - - - -	8,76
George II. - - - - - - - -	8,82
George III. 1771 - - - - - -	8,84
George III. 1772 and 1773 - -	8,86

SILVER.

Silver coined in the Reign of Edw. VI.	10,254
Elizabeth - - - - - - - -	10,284
James I. - - - - - - - -	10,186
Charles I. - - - - - - -	10,260
In the time of the Interregnum -	10,292
Charles II. - - - - - - -	10,280
James II. - - - - - - - -	10,310
William & Mary, & William III.	10,352
Anne - - - - - - - - - -	10,288
George I. - - - - - - - -	10,337
George II. - - - - - - -	10,250

GOLD.

Charles II. - - - - - - - -	17,561
William and Mary - - - -	17,676
William III. - - - - - - -	17,560
Anne - - - - - - - - - -	17,800
George I. - - - - - - - -	17,725
George II. - - - - - - - -	17,758
George III. - - - - - - -	17,780

Whether the intrinsic value of a coinage be in a ratio exactly correspondent to its specific gravity, I shall not take upon me to determine; it is pretty clear, however, that the Gold of the present, and late reigns, is considerably better than that of Charles or William; and the difference between the latter, and that of Anne is remarkable.

A TABLE *of the* SPECIFIC GRAVITY *of various* METALS.

Fine Gold from 19,000 to - - -	19,500
Gold generally deemed ſtandard -	18,888
Sterling Gold, when coined* - -	17,793
Portugal Gold, ditto, from 17,511 to	17,750
Lead - - - - - - - - - -	11,266
Fine Silver from 10,500 to - -	11,000
Sterling Silver, when coined - -	10,378
Fine Copper - - - - - - -	9,000
Sterling Copper, coined - - -	8,830
Plate Braſs, roll'd hard - - - -	8,500
Caſt Braſs from 8,100 to - - -	8,300
Iron from 7,500 to - - - - -	7,800
Block Tin - - - - - - -	7,320
Diamonds of *Eaſt-India* (mean weight)	3,519
Ditto of *Brazil* (ditto)	5,513

*** If the decimal point be taken away from the above ſpecific gravities, or if the ſpec. grav. of any ſubſtance be multiplied by 1000, the product will ſhew how many ounces avoirdupois are contained in a cubic foot of each ſubſtance. A cubic foot of Water, therefore, weighs 1000 ounces, *i. e.* very nearly 62½ pounds avoirdupois; or, 75*lb.* 10*oz.* 16*dwts.* troy.

I might

* The variation in the ſpecific gravity of ſome Guineas coined in the reign of Charles II. and others of George III. has been 0,348; I have met with ſome of the latter whoſe S. G. is 17,848, others of the former no more than 17,500.

I might have enlarged this table of ſpecific gravities very conſiderably, by the addition of various other ſubſtances, but muſt have been obliged, for want of leiſure and opportunity, to have taken them upon truſt, from other tables ready calculated to my hands:——Upon the peruſal of many, I have found them ſo extremely variable from each other, and, in general, ſo extremely variable from the truth, that I thought it much better to omit them.

Since all bodies are ſubject to expanſion by heat, and to contraction by cold, and as ſome ſubſtances expand by heat much more than others, it will follow, that the relative gravities of bodies are, in ſome ſmall degree, liable to conſtant mutation. This, I believe, was firſt obſerved by M. Homberg, and after him by M. Eisenchmid, who by various experiments, found the abſolute weight of a cubic inch of ſeveral kinds of fluids, to be conſiderably greater in winter than in ſummer, and inſtances the following.——A cubic inch of *Water* (the weight of which is nearly about 253 grains in temperate weather) is 3 grains heavier in winter than in ſummer: A cubic inch of *Brandy* 10 grains;—of *Spirit of Nitre* 20 grains;—*Spirit of Vitriol* 5 grains;—*Oil of Vitriol* 12;—*Milk* 5;—*Vinegar* 6. ——But to be correct in this, it is neceſſary that the degrees of heat or cold ſhould be ſpecified by the thermometer.

It

It was before obſerved that, in order to perform any hydroſtatic experiments accurately, it is neceſſary that the reſpective *water balance-weights*, belonging to the *nipper*, *bucket*, &c. ſhould produce an exact equilibrium, and that if they did not, *ſmall weights* (the 20th or 30th part of a grain) might be put into the lighter ſcale, in order to produce a balance. This method will do very well for ſome purpoſes, when ſmall, heavy ſubſtances are to be weighed, ſuch as a piece of gold coin, &c. but when preciſion is required, the alteration of the balance-weight may produce too great an error. To be always correct in theſe experiments, it is neceſſary that the water we make uſe of ſhould be always of one determinate weight; and the balance-weights ſhould never be altered by filing, or other means, after having been once accurately adjuſted to a *temperate* ſtandard. The beſt method of trying the weight of the Water is by ſuſpending in it a body of pretty large contents, ſuch as the glaſs ſolid before mentioned: If, in cold weather, this appears to be rather lighter than the balance-weight, the water is heavier than it ought to be, and it may be brought to the fire for a minute or two, or a little warm water added to it, till it is rendered ſufficiently light. If, when the weather is hot, the water appears too light, by the ſolid's ſubſiding in it beyond an equilibrium, a few grains of common *ſalt* diſſolved in it, will increaſe the gravity to the point required.——The heat or cold-

coldnefs of the weather may produce fome little variation in the fpecific weight of the bodies themfelves, that are to be weighed, but *folid* bodies, in general, are much lefs affected than *fluids*.

The following TABLE being very ufeful and neceffary for Expedition in weighing of different Subftances by Grains, preventing Lofs of Time in Computation; it is intended to be cut out of the Book, and placed in immediate View, when the Hydroftatic Balance is made ufe of.

A TABLE

For reducing Pennyweights into Grains, and the contrary.

*** In Troy Weight, 24 Grains make 1 Pennyweight, 20 Pennyweights 1 Ounce, 12 Ounces 1 Pound.

Dwts.	Grains.	Gr.	Dwts.	Gr.	Gr.	Dwts.	Gr.	Gr.	Dwts.	Gr.	Gr.	Dwts.	Gr.
1	24	25	1	1	53	2	5	81	3	9	109	4	13
2	48	26	1	2	54	2	6	82	3	10	110	4	14
3	72	27	1	3	55	2	7	83	3	11	111	4	15
4	96	28	1	4	56	2	8	84	3	12	112	4	16
5	120	29	1	5	57	2	9	85	3	13	113	4	17
6	144	30	1	6	58	2	10	86	3	14	114	4	18
7	168	31	1	7	59	2	11	87	3	15	115	4	19
8	192	32	1	8	60	2	12	88	3	16	116	4	20
9	216	33	1	9	61	2	13	89	3	17	117	4	21
10	240	34	1	10	62	2	14	90	3	18	118	4	22
11	264	35	1	11	63	2	15	91	3	19	119	4	23
12	288	36	1	12	64	2	16	92	3	20	120	5	—
13	312	37	1	13	65	2	17	93	3	21	130	5	10
14	336	38	1	14	66	2	18	94	3	22	140	5	20
15	360	39	1	15	67	2	19	95	3	23	150	6	6
16	384	40	1	16	68	2	20	96	4	—	160	6	16
17	408	41	1	17	69	2	21	97	4	1	170	7	2
18	432	42	1	18	70	2	22	98	4	2	180	7	12
19	456	43	1	19	71	2	23	99	4	3	190	7	22
20	480	44	1	20	72	3	—	100	4	4	200	8	8
21	504	45	1	21	73	3	1	101	4	5	300	12	12
22	528	46	1	22	74	3	2	102	4	6	400	16	16
23	552	47	1	23	75	3	3	103	4	7	500	20	20
24	576	48	2	—	76	3	4	104	4	8	600	25	—
25	600	49	2	1	77	3	5	105	4	9	700	29	4
		50	2	2	78	3	6	106	4	10	800	33	8
		51	2	3	79	3	7	107	4	11	900	37	12
		52	2	4	80	3	8	108	4	12	1000	41	16

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